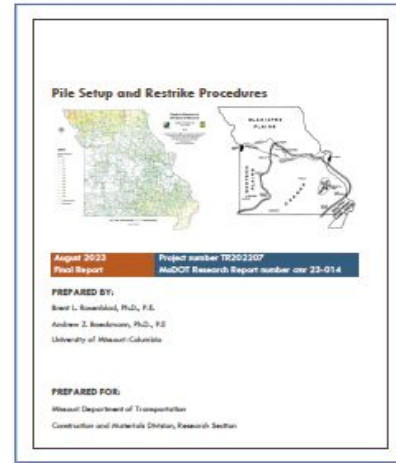


Research Summary

Pile Setup and Restrike Procedures

Friction piles are a common foundation type supporting bridges in Northern and Southeast Missouri. Because bedrock is so deep in these regions the foundation capacity is primarily derived from the friction between the side of the pile and the surrounding soil. When these piles are installed, they are driven into the soil until they reach a depth where they have sufficient capacity to carry the bridge loads. The capacity of driven piles can be measured as the pile is driven using a process called high-strain dynamic testing (HSDT) where stress waves propagating in the pile from the impact of the pile hammer are measured and modeled to determine the load capacity of the pile. Driving piles causes significant disruption to the structure of the soil and generates excess pore water pressures in the soil.

After pile driving is completed, the excess pore pressures slowly dissipate, causing an increase in the stiffness and strength of the soil as well as the capacity of the pile. The capacity of the pile, therefore, will often be at its lowest at the end of driving (EOD) and will continue to increase over days and weeks after installation of the pile. This phenomenon, called pile setup, can be a significant contribution to the long-term pile capacity. However, it is difficult to predict pile setup, as it depends on local soil conditions, as well as pile type and pile size. One approach a designer may take is to stop pile driving short of the needed capacity and come back days later to measure the capacity using a restrike. The ratio



of the capacity at the time of the restrike to the capacity at the EOD is called the setup factor. This approach has the disadvantage of negatively affecting construction schedules.

"The resulting decrease in required pile length is shown to produce cost savings of thousands of dollars per pile..."

The primary objective of this project was to provide MoDOT with reliability-based guidelines and procedures to incorporate pile setup into pile design methods without the need for restrikes. Load test reports from HSDT and associated soil boring data were compiled from bridge sites in Northern Missouri and Southeast Missouri. Load test reports were carefully reviewed and reliable pile test results were selected for inclusion in the pile setup model. Pile setup factors were calculated and plotted versus time to develop a model of setup for the soils in Northern Missouri (Figure 1) and Southeast Missouri. Soil boring information was used to classify the soil profile conditions as Sand, Clay or Mixed.

The pile setup model from Northern Missouri HSDT data was used in a reliability-based analysis to probabilistically calibrate resistance factors for the design scenario of relying on pile setup without demonstrating setup through restrikes. Resistance factors of 0.38 and 0.09



were calculated for piles in Clay and Mixed profiles, respectively, considering a 1 in 10,000 probability of failure. A new section in the Engineering Policy Guide provisions titled *Friction Piles in Northern Missouri* is proposed that uses these resistance factors to account for pile setup without the need for restrikes.

The primary effect of applying the proposed provisions is to reduce the required nominal EOD resistance compared to the common practice of neglecting pile setup unless restrikes are performed. The reduction in the nominal EOD resistance is shown to be as much as 27% for Clay profiles and 11% in Mixed profiles. The resulting decrease in required pile length is shown to produce cost savings of thousands of dollars per pile, as compared to the case of not considering pile setup. In addition, this approach avoids construction delays associated with pile restrikes.

The data from Southeast Missouri was insufficient to perform a reliability-based analysis, as was done for the Northern Missouri sites. However, the limited data suggest that moderate pile setup does occur in Southeast Missouri. In fact, half of the piles had setup factors between 1.0 and 1.2, one had a setup factor of 1.3, and the pile with the greatest setup had a setup factor of nearly 1.6. Collection of additional load test data would facilitate development of resistance factors for piles installed in Southeast Missouri soils.

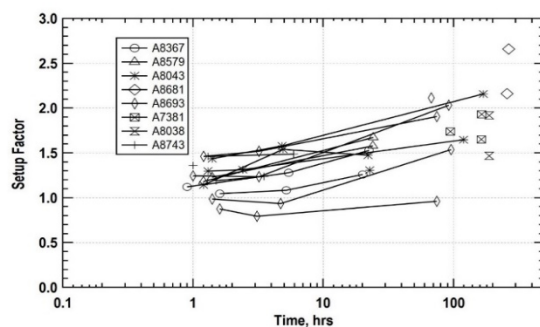


Figure 1: Pile setup factors versus time from Northern Missouri sites—all profiles.

Project Information

PROJECT NAME: TR202207—Pile Setup and Restrike Procedures

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LEAD CONTRACTOR: University of Missouri-Columbia/MCTI

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CONTACT INFORMATION:

Brent Schulte

Senior Research Analyst
Missouri Dept. of Transportation
1617 Missouri Blvd.
Jefferson City, MO 65109
(573) 526-4328

Brent.Schulte@modot.mo.gov

